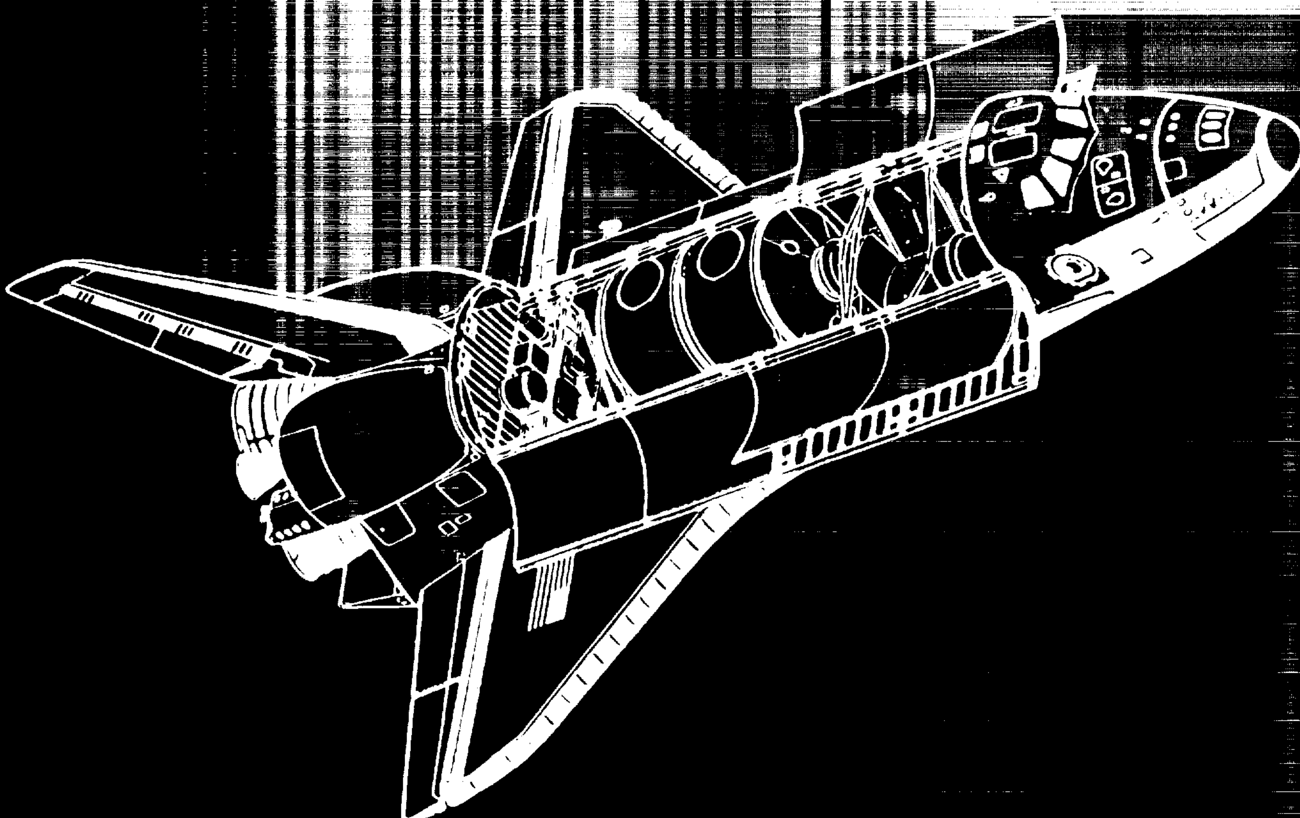
NASA

Microgravity Strategic Plan - 1990



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Washington, DC 20546

This report has been prepared as an internal OSSA document, and it will serve as the basis for OSSA program planning in the future.

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MISSION STATEMENT

As part of its mandate to guide the United States' civil space program, the National Aeronautics and Space Administration (NASA) is committed to preserving U.S. preeminence in critical aspects of space science, applications, and technology. NASA's goals include obtaining scientific, technological, and economic benefits through space-related activities, encouraging U.S. private sector investment in space, and improving the quality of life on Earth.

The NASA Office of Space Science and Applications (OSSA) is responsible for planning and executing a major portion of the activity associated with the above goals. The OSSA Microgravity Science and Applications Division (MSAD) is responsible for administering NASA's microgravity science program and the Office of Commercial Programs is responsible for facilitating the commercial use of space through its Commercial Development Division. In carrying out this NASA goal, both divisions work closely with one another to insure a comprehensive NASA-wide Microgravity Program. The mission of the program is to utilize the unique characteristics of the space environment, primarily the near absence of gravity, to expand man's knowledge of physics, chemistry, materials and fluid sciences, and biotechnology; to understand the role of gravity in materials processing; and, where possible, to demonstrate the feasibility of space production of improved materials that have high technological, and possible commercial, utility.

INTRODUCTION

The overarching objective of the NASA Microgravity Program is the utilization of space as a laboratory to conduct basic research and development. The on-orbit microgravity environment, with substantially reduced buoyancy forces, hydrostatic pressures, and sedimentation, will enable us to conduct scientific investigations not possible on Earth. This environment allows many processes to be isolated and controlled and many measurements to be made with an accuracy that cannot be obtained in the terrestrial environment. As extraterrestrial bodies are explored, microgravity science will also include scientific investigations at differing gravity levels.

The areas of research and development to be conducted in this "laboratory in space" encompass 1) fundamental science, which includes the study of the behavior of fluids, transport phenomena, condensed matter physics and combustion science; 2) materials science, which includes electronic and photonic materials, metals, alloys, glasses and ceramics; and 3) biotechnology, which focuses on macromolecular crystal growth and cell science, such as purification technologies. Experiments in these areas typically seek to provide observations of complex phenomena and measurements of physical attributes with precision enhanced by the microgravity environment. These results are used to challenge and validate contemporary scientific theories. Also, applied microgravity research conducted by NASA and its industrial partners could provide fundamental insights that would lead to a better understanding of Earth-based processes and the space-based production of new materials with unique properties.

Pioneering science efforts such as these can stimulate exciting developments in technology and space commercialization that will contribute to economic growth of our country in the 21st century. Successful exploitation and development of the near-Earth space environment utilizing the Space Shuttle, expendable launch vehicles, and the Space Station Freedom, as well as the exploration and utilization of extraterrestrial bodies, requires a vision of the future with well-defined goals consistent with national interests and well-conceived strategic, development and operational plans.

This document is NASA's agency-wide strategic plan for its Microgravity Program. It addresses research, applications, and commercialization for the 1990s. The plan presents an analysis of the current status of the microgravity program, identifies critical factors, and defines goals, priorities, and strategies which are intended to:

- Support the formulation and execution of a program consistent with national goals in space.
- Define the steps toward obtaining unique, high quality science data utilizing NASA's low-gravity facilities, both on the Earth and in space.
- Define the criteria for decision making regarding program structure, content, and priorities.
- Establish a structure for long-range planning of scientific research and spacecraft hardware development within the budget allotment.
- Develop an infrastructure and scientific and technology data bases such that academia, private industry, other government agencies, and foreign partners can become active users of the laboratory in space for research and commercial purposes.

JUL 10

L. A. Fisk
Associate Administrator for
Space Science and Applications

VISION OF THE FUTURE

By the turn of the century the use of space as a laboratory to conduct experimental and applied commercial research in a microgravity environment will be an active, widely accepted endeavor. An expanded and strengthened infrastructure for microgravity research will exist in which a broad community of researchers will participate. New areas of microgravity research will emerge. Improved ground and space-based facilities will be in place. Orbiting platforms and free flyers will be used for research requiring long duration, high quality microgravity environment with minimal human intervention. U.S. preeminence in space research and applications will be continued through the operation of the Space Station Freedom in near-Earth orbit. The U.S. and its international partners will all benefit from this permanently manned facility.

Our ground-based and space-borne research will: 1) contribute substantially to our knowledge and understanding of fundamental science; 2) build foundations for new techniques in Earth-based materials processing through advances in materials science; and 3) enhance our quest to understand the growth, structure, and regulatory processes of biological molecules, cells and tissues.

By the beginning of the next century, human exploration activities beyond near-Earth orbit will have renewed emphasis. Plans to establish a manned lunar outpost are currently being evaluated. Potential research facilities, and even the extraction of oxygen from lunar soils, are under consideration for the first decade of the 21st century. Scenarios in which humans visit Mars within the next 30 years are also being explored. Therefore, eventual use of extraterrestrial space as a research laboratory necessitates its consideration in our plans as well. Our vision of the future, then, includes these expectations on its horizon:

- Routine use of knowledge gained from space research;
- An established infrastructure that facilitates access to space-based laboratories;
- The beginning of opportunities to perform research in space and on extraterrestrial bodies beyond near-Earth orbit.

The Microgravity Strategic Plan for 1990 sets forth a list of five goals and a strategy to attain these goals that will lead us in a cost effective and timely manner into the future.

GOALS OF THE NASA MICROGRAVITY PROGRAM

The following five goals for the NASA Microgravity Program reflect a merging of our vision of the future, considerations of the current status of the program, and the space science, applications, and commercialization objectives:

Goal 1. Develop a comprehensive research program in fundamental sciences, materials science and biotechnology for the purpose of attaining a structured understanding of gravity dependent physical phenomena in both Earth and non-Earth environments.

Goal 2. Foster the growth of an interdisciplinary research community, united by shared goals and resources, to conduct research in the space environment.

Goal 3. Encourage international cooperation for the purpose of conducting research in the space environment.

Goal 4. Utilize a permanently manned, multi-facility national microgravity laboratory in low-Earth orbit to provide a long-duration, stable microgravity environment.

Goal 5. Promote industrial applications of space research for the development of new, commercially viable products, services, and markets resulting from research in the space environment.

CURRENT STATUS

NASA's Office of Space Science and Applications (OSSA), through its Microgravity Science and Applications Division (MSAD), conducts a program of basic research on the ground and in the space environment. Its purpose is to utilize the characteristics of the space environment, primarily the near absence of gravity, to expand man's knowledge of physics, chemistry, materials and fluid sciences, and biotechnology. In addition, MSAD pursues applied research in materials science and biotechnology to enable technological advances. These NASA-funded investigations are conducted by university, industry, and government researchers using both ground-based facilities and and aerospace flight instruments.

The Microgravity Program uses an evolutionary approach to conduct space research of the highest quality. The process starts with new ideas arising from individuals or teams of investigators. Proposals are peer reviewed and, if accepted, are approved for ground-based or flight development, depending on the maturity of the concept. New ideas undergo a ground-based definition stage to allow progress in supporting theory and experimental data and the development of sharply focused flight objectives. Some hypotheses may be refined or confirmed and their associated flight apparatus validated using ground-based reduced-gravity facilities. In these facilities, reduced-gravity test environments of varying durations are available: up to 5 seconds in drop towers and drop tubes, 30 seconds in aircraft, and up to 15 minutes in suborbital rockets. To support those investigations requiring longer periods of reduced-gravity in the most cost effective manner, the microgravity flight program uses a broad base of available carriers and carrier resources, including the Space Shuttle Orbiter with its middeck, cargo pallet, Spacelab, and Get-Away-Special (GAS) canisters.

The Division is currently exploring options for the use of suborbital rockets and free-flyers for experiments that do not require the longer Shuttle flights or manned intervention, respectively.

In the latter part of the 1990s, Space Station Freedom will provide additional capabilities to conduct microgravity research, particularly with respect to greater experiment duration and flexibility. Six multiuser microgravity facilities are now being defined for potential use on Space Station. Hardware requirements which are necessary to support the facilities are also being identified in order to influence Space Station design. Precursor apparatus flown on the Shuttle will provide experience with operations and development of instrumentation and subsystems for use in these space facilities. Additional emphasis will be placed on development of telescience and automation in order to effectively use the Space Station Freedom facilities.

The near-term microgravity effort has an aggressive flight program planned for a number of Shuttle flights in the near future. Microgravity payloads are scheduled for flight as middeck, Spacelab, and GAS experiments on a number of Shuttle missions. The major near-term opportunities for microgravity science and applications payloads are the International Microgravity Laboratory (IML), the United States Microgravity Laboratory (USML), and the United States Microgravity Payload (USMP) series of flights. Principal Investigators have recently been selected to conduct experiments to be flown on USML-1 in 1992 and on IML-2 in 1993. A NASA Research Announcement (NRA) for research in combustion science was released in December 1989. Evaluation of the proposals will be completed in fiscal year 1990 and researchers will be funded beginning in 1991. The microgravity mission planning schedule showing the major microgravity missions and the hardware to be flown is shown in Figure 1. Shown in the figure are the various microgravity flight experiments, the flight year, and the various missions on which they fly. For example, the Fluid Experiment System will fly on IML-1 in 1990; Protein Crystal Growth will fly on IML-1 in 1990 as well as on two additional middeck flights. This mission planning schedule will continue to evolve as programmatic decisions are made.

The flight program also contains an advanced technology effort. The purpose of this effort is to develop advanced measurement techniques and experimental methodologies necessary to support future experimentation.

As a further adjunct to the flight program a new initiative is under consideration to support several significant fundamental science experiments which are now ready to proceed to flight development. Numerous peer reviews have determined that the scientific merit of the experiments warrant flight opportunities. However, these flight experiments generally lie outside the current and planned microgravity flight hardware capabilities.

The ground-based program continues to perform its essential, historical functions of providing theoretical and experimental efforts to support, and to thoroughly understand the results of the current flight experiments; and to nurture the ideas and efforts which might later form the basis of a flight experiment. The additional resources necessary to maintain the level of experimental effort needed to produce the high quality flight experiments of the future will be the subject of an augmentation under consideration for the early 1990s.

The Division is currently developing plans for the release of Announcements of Opportunity (AO) and additional NRA's which will be used to continue to obtain high quality science investigations. Upon acceptance for the ground-based program, a Principal Investigator (PI) can pursue a three year project that is reviewed annually. In the flight program, an investigator is funded for definition or flight development depending on the experiment's initial level of maturity. Transition from experiment definition to flight development is accomplished via a structured review process which examines the scientific and technical progress of the investigation.

The President's speech of July 20, 1989, highlighted a new program, now called the Space Exploration Initiative (SEI), calling for a permanently manned lunar base and a Mars outpost for research and resource development. The Microgravity Program supports this new initiative by developing a thorough understanding of gravity-dependent physical phenomena. That understanding will form the basis for the technological capability required for safe and efficient operations in interplanetary spaceflight and in non-Earth environments.

NASA's Office of Commercial Programs (OCP) sponsors focused industrial research and program initiatives that encourage the participation of U.S. industry in space endeavors. OCP-sponsored Centers for the Commercial Development of Space (CCDS) represent the method by which universities and non-profit institutes, with committed industry partnerships, participate in an industry-driven microgravity research program. NASA provides seed money, normally for five years, to develop research centers at universities and non-profit institutes that will ultimately be supported by industry contributions. The proposing institution forms a partnership with various industries that share a common interest and commitment to focused and/or applied space research. A major consideration in selecting such a center is the amount of commercial commitment and actual contribution. There are presently seven such centers committed to industry-driven microgravity research. An eighth is conducting industrial research in thin films and superconducting materials using the "ultra-vacuum" of space. They provide an excellent mechanism for combining academic and industrial research to ensure that experiments have industrial objectives.

In addition to flying an experiment on the Shuttle through a CCDS, industry can also propose payloads directly through a Joint Endeavor Agreement (JEA), a Space System Development Agreement (SSDA), or a Launch Services Agreement (LSA). Each type of agreement enables industry, at different phases in the product cycle, to fly payloads in space. As mentioned previously, industry can also compete for funding from the MSAD program.

NASA's principal role in commercial development of space is to provide flight opportunities addressing industry-driven technology requirements. Industry requires the conduct of a vigorous, high-quality research program in which frequent flight opportunities, prompt review procedures, and rapid reporting of results will provide the data base necessary to gain the understanding of physical phenomena from which commercial ventures can confidently emerge. A large measure of NASA's success in developing the space frontier will be the degree to which industry, universities, and other government agencies participate and invest in space research, development, and commercialization efforts.

Figure 1. Microgravity Science and Applications Division Mission Planning Schedule

Flight Experiment	CY90	CY91	CY92	CY93	CY94	CY95	CY96	CY97	CY98	CY99	CY00
Fluid Experiment System	IML-1							IML-4			
Vapor Crystal Growth System	IML-1							IML-4			
Protein Crystal Growth	IML-1/MD(2)	SLJ/MD	USML-1/MD(2)								
Shuttle Acceleration Measurement System	IML-1/SLS-1	SLJ/MD(3)	MD(2) USML-1/USMP-1	MD(2), USMP-3, IML-2, USMP-2	USMP-4/MD(2) USML-2	IML-3/MD(2)	MD(2) USML-3/USMP-5	IML-4/MD(2)	USML-4 MD(2)	IML-5	USML-5
Solid Surface Combustion Experiment	SLS-1		USML-1	IML-2	USML-2		USML-3		USML-4		
Gallium Arsenide Experiment	SLS-1		USMP-1				USMP-5				
Drop Physics Module			USML-1				USML-3		USML-4		
Crystal Growth Furnace			USML-1		USML-2		USML-3		USML-4		USML-5
Surface Tension Driven Convection Experiment			USML-1		USML-2			IML-4			
Glovebox			USML-1		USML-2		USML-3		USML-4		
Lambda Point Experiment			USMP-1				USMP-5				
Advanced Protein Crystal Growth				IML-2/MD(2) USMP-3	USML-2/MD(2)	IML-3/MD(2)	USML-3/MD	IML-4/MD	USML-4/MD	IML-5	USML-5
Advanced Automated Directional Solidification Furnace				USMP-2 USMP-3	USMP-4		USMP-5				
Critical Fluid Light Scattering				USMP-3							
Isothermal Dendrite Growth Experiment			USMP-1		USMP-4		USMP-5				
Geophysical Fluids Flow Cell					USML-2						
Combustion Module 1							USML-3		USML-4	IML-5	
Combustion Module 2									USML-4		USML-5
Fluids Module 1								IML-4		IML-5	
Fluids Module 2										IML-5	
Programmable Multi-Zone Furnace							MD(2)	MD(2)	MD(2)		
Advanced Protein Crystal Growth Facility Module (1)							SSF →				
Advanced Protein Crystal Growth Facility Module (2)							SSF →				
Space Station Furnace Facility, Module (1)								SSF →			
Modular Containerless Processing Facility, Module (1)									SSF →		
Space Station Furnace Facility, Module (2)										SSF →	
Modular Containerless Processing Facility, Module (2)										SSF →	
Modular Combustion Facility, Module (1)											SSF
Advanced Protein Crystal Growth Facility Module (3)											SSF

NOTES:

- IML 1 - 5 — International Microgravity Laboratory Mission 1 through 5
- USML 1 - 5 — United States Microgravity Laboratory Mission 1 through 5
- USMP 1 - 5 — United States Microgravity Pallet Mission 1 through 5
- MD — Middeck (numbers in parentheses after MD indicate number of MD flights per year)
- SSF — Space Station Freedom
- SLS-1 — Spacelab Life Sciences Mission 1
- SLJ — Japanese Spacelab

[Launch dates from NASA Mixed Fleet Manifest, dated January 1990]

Mission planning schedule will evolve as programmatic decisions are made

DECISION RULES AND PRIORITIES

The utilization of space as a laboratory in which to conduct research and development is an endeavor of considerable magnitude and responsibility with a potential stream of benefits to our educational system and for many sectors of our economy. The challenge facing the Microgravity Program is to make optimal use of this laboratory while conducting research in the most cost effective manner. Therefore, it is necessary to establish decision rules and priorities within the decision rules in order to guide the decision-making process.

The Microgravity Science and Applications Division develops its decision rules within the bounds of, and closely attuned to, the Strategic Plan of the Office of Space Science and Applications. The microgravity decision rules and the associated priorities are as follows:

1. *Maintain and complete the ongoing program*

   The completion of the ongoing program remains our highest priority. This includes our commitment to the USML, IML, and USMP series of flights for those experiments whose development costs continue to be supported by projected science return; the development of apparatus for secondary payloads; and the ground-based science program.

2. *Identify and nurture new experimental concepts and new areas of investigation*

   While the completion of our ongoing program must remain our first priority, the development and maturation of new flight experimental concepts and new areas for scientific investigations represents our immediate second priority in order to maintain a vigorous future program. These activities are focused toward expanding microgravity research in new fields of science and addressing "critical issues" identified in the research program. Also included are university programs to encourage participation in microgravity research.

3. *Move aggressively, but sensibly, toward the capability for experimentation on Space Station Freedom*

   Much of the future microgravity experimentation will be performed on Space Station Freedom. We must therefore move aggressively to take advantage of the unique capabilities the Space Station will afford. We are currently developing concepts for facilities to be used on Space Station to support multiple experiments by the substitution of different modules. NASA is also developing advanced technology to support new and innovative experiments on the Space Shuttle and Space Station.

4. *Selectively identify new initiatives as required to support the Microgravity Program*

   Several opportunities for further efforts have been identified which would significantly enhance the microgravity program. These efforts are under consideration as future augmentations and new initiatives, consistent with OSSA's strategic planning efforts. These include an augmentation to the Ground-Based Program for Fundamental Science and Advanced Technology Development and a new initiative for the Flight Program for Fundamental Science, as well as support for Space Station Freedom Integration and Operations. Brief summaries of these proposed initiatives and augmentations are included in Appendix A.

IMPLEMENTATION STRATEGIES

The five major Microgravity Program goals which are restated in this section will be achieved through the flight experiment and ground-based programs via the execution of strategies identified below:

Goal 1. Develop a comprehensive research program in fundamental sciences, materials science, and biotechnology for the purpose of attaining a structured understanding of gravity-dependent physical phenomena in both Earth and non-Earth environments.

- Utilize expert advisory bodies such as the Microgravity Science Committee of the Space Studies Board, the Microgravity Subcommittee of the Space Science and Applications Advisory Committee, the Discipline Working Groups, and other advisory committees to identify new opportunities as well as critical issues in the current program.

- Follow an evolutionary approach to research in which experiments are developed on the ground, tested, refined and carefully selected for Shuttle flights, or where appropriate, continued on free flyers or Space Station Freedom.

- Continue to develop investigator-driven multiuser modular experimental hardware for the purpose of maximizing science return while reducing life cycle cost.

- Continue to develop experiment-specific hardware for high-value experiments which cannot be performed via multiuser hardware.

- Continue to support the USML, IML, and USMP series of missions through proposal solicitation and hardware development.

- Encourage new investigators to participate in the Microgravity Program via the periodic release of solicitations.

- Accommodate maturing ground-based research via a continuing assessment of the needs for the development and flight of new PI-specific experiment apparatus, and for additional flight opportunities including free flyers and other carriers.

- Support the orderly expansion of the ground-based research efforts to involve additional ground-based PI's, identify and develop advanced technologies, and fully exploit ground-based laboratories, facilities, and suborbital carriers.

- Apply the capabilities of ground-based research and flight experiments to address the behavior of processes in non-terrestrial environments in support of the Space Exploration Initiative.

Goal 2. Foster the growth of an interdisciplinary research community, united by shared goals and resources, to conduct research in the space environment.

- Continue to support forums and workshops, such as Gordon Research Conferences, American Institute of Aeronautics and Astronautics Aerospace Sciences Meetings, COSPAR Conferences, International Aeronautics Federation Conferences, and European Symposia on Material and Fluid Science in Microgravity, which disseminate information to the scientific community at large regarding microgravity research.

- Enhance the support of microgravity research in the academic community via development of an undergraduate research program, continued use of graduate student fellowships, and expansion of post-doctoral fellowship awards.

- Increase multiagency opportunities for participation in microgravity research via the Space Station Science and Applications Utilization Board (SSSAUB).*

Goal 3. Encourage international cooperation for the purpose of conducting research in the space environment.

- Continue to utilize international interfaces through government agencies and committees.

- Promote participation in the IML series of missions through

* The SSSAUB is constituted for the purpose of developing the United States science utilization of Space Station Freedom and representing that utilization to the U.S. Space Station Users Board.

solicitations to U.S. and foreign investigators for the utilization of both foreign and domestic experiment apparatus.

- Investigate the possibilities of international cooperation for future development of selected experiment apparatus.

Goal 4. Utilize a permanently manned, multi-facility national microgravity laboratory in low-Earth orbit to provide a long-duration, stable microgravity environment.

- Continue to pursue the evolutionary development of investigator driven multiuser, facility-class hardware to be utilized on Spacelab and Space Station Freedom.

- Continue to maintain a systems engineering effort to examine subsystem commonality requirements among different experiments and Space Station Freedom facilities to minimize overall experiment module and facility development cost.

- Continue to review the Space Station Freedom proposed design and recommend changes to enhance the environment for conducting microgravity research.

- Participate in the development of OSSA's Consolidated Operations and Utilization Plan for Space Station.

- Support the development of the integration, operations, and training activities for Space Station Freedom.

Goal 5. Promote industrial application of space research for the development of new, commercially viable products, services, and markets resulting from research in the space environment.

- Continue to support the Centers for the Commercial Development of Space.

- Maintain coordination with the Technology Utilization Office in order to make use of existing technology transfer methodologies and to develop new methodologies where appropriate.

- Promote university/NASA/industry research links in order to enhance the U.S. science and technology base.

- Conduct space-based production of small quantities of high-value materials, such as those used in electronic/optical sensors.

- Continue to develop new processes and processing techniques that exploit the microgravity environment, such as those used in crystal growth and containerless processing.

APPENDIX A
FUTURE INITIATIVES AND AUGMENTATIONS

In order for the MSAD to accomplish its stated goals in the most effective manner the following New Initiatives and Augmentations are presently under consideration and are being developed consistent with the OSSA Strategic Plan. These are described below.

<u>*Microgravity Fundamental Science and*</u>
<u>*Advanced Technology Development Ground-Based Augmentation*</u>
Proposed Research Base Enhancement Augmentation

Historically, the mainstay of the Microgravity Program has been the nurturing of high quality, ground-based investigations leading to definition and development of microgravity experimentation. The principal objective of these ground-based laboratory investigations is to analytically and experimentally develop the basis for flight experiments. Closely coupled with the expansion of the ground-based program is the need for advanced development of measurement, diagnostic, and characterization techniques to facilitate future flight investigations, and for the capability to use suborbital flights to obtain greater experiment time in reduced gravity than that available via ground-based facilities or aircraft.

The fundamental microgravity research program will be strengthened in several areas:

1. By developing a ground-based research program of sufficient vigor to assure that the widening opportunities for flight experiments in the Space Station era will be optimally utilized.

2. By enlarging the microgravity measurement analysis efforts to characterize the gravity environment on Spacelab, and to define more precisely the acceptable levels for future experimentation.

3. By developing measurement technology and specific experimental subsystems required to enable the desired experiments.

4. By enhancing the infrastructure for ground-based experimentation including the use of suborbital carriers.

5. By enhancing the educational opportunities in the college community through undergraduate and post doctoral programs as well as a special

grant program to acquaint beginning faculty with microgravity research.

Microgravity Fundamental Science Flight Initiative
Proposed Small Missions Initiative

A number of fundamental physical and chemical laws can be investigated through access to the low-gravity environment of spaceflight. Investigations in fundamental research using experiment-specific hardware would challenge a broad range of contemporary theories in condensed matter physics and general relativity. A program involving small-scale investigations can use the Space Shuttle, small dedicated free flyers, Space Station Freedom, and possibly commercial platforms as vehicles on which to conduct research of this nature. The scientific merit and desirability of developing opportunities in this area are cited by the Space Science Board in *Space Science in the Twenty-First Century: Imperatives for the Decades 1995 to 2015 – Fundamental Physics and Chemistry.*

Space Station Freedom
Integration and Operations Augmentation
(Microgravity Support)

As the planning for Space Station Freedom proceeds, it is recognized that it is necessary to prepare for the physical and analytical integration of the flight hardware, the operations of that flight hardware by investigator teams with members in the Space Station as well as on Earth and the training of the investigator teams prior to flight. The purpose of this initiative is therefore to strengthen the planning for the use of Space Station Freedom by:

1. Identifying and developing the methodology and infrastructure necessary to accomplish the analytical and physical integration of the flight hardware.

2. To define and develop the appropriate operational structure with the necessary operational centers and personnel such that flight experiments can be conducted efficiently.

3. To define and develop the necessary crew training programs and requirements such that flight experiments can be conducted efficiently.

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